**The Race to Mars:**

**How SpaceX ranks against the competition0 New,**

**Who will get to the Red Planet first?**

by [Rachel Becker](https://www.theverge.com/users/RachelBecker)

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* share Linkedin On Tuesday, SpaceX CEO Elon Musk announced [his ambitious — if crazy — plan](http://www.theverge.com/2016/9/28/13086980/spacex-elon-musk-mars-plan-problems-breathing-radiation-death) to colonize Mars within the next 40 to 100 years. But Musk isn’t the only one with Mars dreams and ambitions. In fact, people have been drawing out missions to the Red Planet for [at least the last 70 years](http://news.nationalgeographic.com/2015/11/151111-mars-mission-fail-history-astronaut-science/) — and we’re still waiting for one to take flight.

**How do the most prominent plans stack up?**

One of the early proposed missions that set the stage for today’s Mars plans was the [Mars Direct](http://www.marspapers.org/paper/Zubrin_1991.pdf) proposal, which was published by aerospace engineers Robert Zubrin and David Baker in 1991. They thought it might be possible to land the first crewed mission to Mars as early as 1999. That didn’t happen of course, but some of their ideas — like sending a return vehicle to Mars before sending a human crew and making propellant from the planet’s resources — are still considered viable options.

Among Musk’s competition there’s NASA, of course, which intends to send astronauts to Mars sometime in the 2030s. And then there’s Mars One, which is planning a one-way trip to the Red Planet by the year 2026. All missions to Mars will be massive — and expensive — undertakings. There’s still a lot we need to figure out to land heavy cargo on Mars and to protect people from radiation while traveling in space. Then there’s the life-support system on the planet itself. We need to figure out how to create habitats that have electricity, sanitation, clean air, and potable water. And what about food supplies and spare parts when things break down?

Considering all the challenges, how do the most prominent plans stack up?

**NASA’s Journey to Mars**

In 2010, President Obama signed the NASA Authorization Act and tasked NASA with extending the human footprint beyond Earth’s orbit. So the space agency shuttered [its shuttle program in 2011](http://gizmodo.com/why-did-nasa-end-the-space-shuttle-program-1721140493) to focus on its nebulous "[Journey to Mars](http://www.nasa.gov/sites/default/files/atoms/files/journey-to-mars-next-steps-20151008_508.pdf)" plan. NASA’s goal is to send humans to Mars [sometime in the 2030s](http://www.nasa.gov/content/nasas-journey-to-mars), but the agency has been [roundly criticized by members of Congress](http://www.theverge.com/2016/2/3/10908408/congress-nasa-journey-to-mars-no-plan-or-money) and experts in the field for lacking details, direction, and a hard deadline.

"What we have right now from NASA is the decision that it should be done — someday," says Zubrin, current president of the Mars Society. "They view it as a goal of the human spaceflight program, but they have no program, they have no schedule — not really."

NASA’s plan breaks down into three phases. During the first one, which is currently ongoing, NASA is testing life support, communication technologies, and human health on the International Space Station. NASA’s [Twins Study](https://www.nasa.gov/twins-study/research),forexample, compares how a year in space has affected retired astronaut [Scott Kelly](http://www.space.com/32907-scott-kelly-astronaut-biography.html)’s body compared to his Earthbound twin, astronaut [Mark Kelly](http://astronautmarkkelly.com/).

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In its second phase, NASA will test drive spacecraft and habitation facilities in the space around the Moon. The space agency is currently developing a crew capsule called "[Orion](http://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orion-58.html)" that will [fit onto the massive](http://www.theverge.com/2015/10/24/9604846/nasa-space-launch-system-mars-rocket-burnt-orange), heavy-lift rocket called the ["Space Launch System," or SLS.](http://www.nasa.gov/exploration/systems/sls/overview.html) NASA [tested Orion in 2014](http://www.theverge.com/2014/12/5/7338839/the-first-test-flight-of-nasas-new-orion-spacecraft), and parts of the SLS [earlier this summer](http://www.theverge.com/2016/6/27/12039228/nasa-rocket-booster-test-watch-space-launch-system). The first integrated test flight is scheduled for [2018](http://www.nasa.gov/press-release/nasas-space-launch-system-booster-passes-major-milestone-on-journey-to-mars), [according to the NASA plan](http://www.nasa.gov/press-release/nasas-space-launch-system-booster-passes-major-milestone-on-journey-to-mars).

In its third phase, scheduled for sometime in the 2030s, NASA will send astronauts to the Red Planet. But the space agency has a lot to figure out — like habitats and life-support systems — before that’s possible.

And its plans will probably continue to shift and adapt as robotic missions to Mars send back new information about the Red Planet. [In the summer of 2020](http://mars.nasa.gov/mars2020/mission/overview/), NASA intends to send a new robotic rover to the Red Planet. One of the instruments on the [Mars 2020](http://mars.nasa.gov/mars2020/mission/rover/) rover is called [MOXIE](http://mars.nasa.gov/mars2020/mission/instruments/moxie/for-scientists/),a device designed to split the carbon dioxide in Mars’s atmosphere into carbon monoxide and oxygen. That could be used one day to make propellant for a return trip to Earth.

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"MOXIE is about doing science on Mars for people further in the future," says Michael Hecht, assistant director of research management at MIT’s Haystack Observatory and the principle investigator of the MOXIE project. "It’s a very future looking payload."

Given the way NASA tends to [get jerked around at election time](http://www.theverge.com/2016/8/23/12603978/nasa-space-policy-2016-presidential-election), it’s not clear whether the space agency will be given the go ahead, or enough funding, in the future to see its Journey to Mars to completion. Many, however, think that if we really want to get to Mars, NASA is our best bet. "Only NASA has all the capabilities to do something like this," says [Scott Hubbard](http://www.planetary.org/about/board-of-directors/scott-hubbard.html), the former director of NASA’s Ames Research Center, who is currently a professor at Stanford and a director of the [Planetary Society](http://planetary.org/).

**NASA Jet Propulsion Laboratory’s Minimal Mars Plan**

Another Mars plan comes from a [team of scientists at NASA’s Jet Propulsion Laboratory](http://online.liebertpub.com/doi/pdf/10.1089/space.2015.0018) in Pasadena, California. This plan would first focus on getting people into orbit around Mars, and then send them to the surface.

<img src="https://cdn.vox-cdn.com/uploads/chorus\_asset/file/7193205/mars.0.jpg" alt="mars from space"> *NASA*

The first trip — which would include a side trip to one of Mars’ moons, Phobos— could happen as soon as 2033. The second and more challenging part of the mission — getting people on the planet — would take place in 2039. The [Planetary Society estimated that this plan](http://planetary.s3.amazonaws.com/assets/pdfs/advocacy/2015/Planetary-Society--Humans-Orbiting-Mars-Workshop-Report-%5BFinal.v2%5D.pdf) could fit within NASA’s existing budget, adjusting for inflation. That is, as long as NASA stops supporting the International Space Station by 2024 — [which it currently plans to do](https://oig.nasa.gov/audits/reports/FY14/IG-14-031.pdf) — or at the latest, by 2028.

"With some bumps and wiggles, if you take NASA’s human spaceflight budget, you can fit this 2033 mission inside that budget line," Hubbard says. "It doesn’t take extraordinary gazillions of new dollars, and you can do it provided that you constrain your goals and your appetites to just what you need to do the job."

**Mars One**

The Netherlands-based nonprofit company Mars One has been recruiting volunteers for a one-way trip to Mars [since 2013. The plan is to depart in 2026](http://www.mars-one.com/mission/roadmap), using technology [that "already exists"](http://www.mars-one.com/mission/the-technology) the company says. The problem is, it doesn’t. The Mars One mission has been called out repeatedly for not having the technology, the money, or a realistic plan to get people to Mars and keep them alive once they’re there.

The reason for the one-way ticket, according to [Mars One’s website](http://www.mars-one.com/), is that the "most complex, expensive, and risky part of a mission to Mars is the return trip." By contrast, "permanent settlement is not very complex," the website says. But a group of MIT graduate students begged to differ.

In 2014, [they presented an analysis](http://www.sciencedirect.com/science/article/pii/S0094576515004294) that revealed a one-way trip is a hugely expensive prospect because the colonists will need a constant resupply of spare parts and equipment to keep critical systems like life support running. "One way has no end — so you have to support the crew on Mars until they die," says [Koki Ho](http://www.ae.illinois.edu/directory/profile/kokiho), one of the authors of the paper and now a professor at the University of Illinois Urbana-Champaign. "That is a large commitment."

"You have to support the crew on Mars until they die."

The MIT study also found that people in the Mars One colony would die within the first few months. The life-support tech required to keep people alive on Mars isn't advanced enough or just doesn't exist yet, the study authors concluded. "You're going one way to an extreme environment where you can't breath if you step outside," says [Sydney Do](http://strategic.mit.edu/alumni.php#do), an author of the study who is currently a postdoctoral aeronautics and astronautics scientist at MIT. "It's like if you were to take a one way trip underwater without the City of Atlantis to receive you."

In a debate against the MIT researchers last year, Mars One CEO [Bas Lansdorp](http://www.mars-one.com/about-mars-one/team/bas-lansdorp) didn’t [address their concerns with his plan.](http://www.theverge.com/2015/8/18/9166697/mars-one-plan-mit-debate-ceo-bas-lansdorp)

**SpaceX**

Then there’s Elon Musk, who thinks that colonizing the Red Planet — and becoming an interplanetary species — is our best bet for survival. In his speech, Musk detailed his plan to create a self-sustaining Mars colony of 1 million people over the next 40 to 100 years. Musk focused mainly on the [new types of vehicles SpaceX](http://www.theverge.com/2016/9/27/13058990/mars-mission-spaceship-announced-elon-musk-spacex) will build to get to Mars: a massive reusable rocket booster and a huge spaceship — [probably to be named "Heart of Gold"](http://www.theverge.com/2016/9/27/13081036/spacex-mars-spaceship-hitchhikers-guide-to-the-galaxy/in/12838307) in a nod to Douglas Adams’ *Hitchhiker’s Guide to the Galaxy*.

Musk’s new plan is heavy on engineering, but light on details about funding and, especially, about how he plans to keep people alive on the ride to Mars and on the planet’s surface. There was no discussion of [habitats](http://www.theverge.com/2016/9/27/13008010/elon-musk-mars-habitat-design-human-life-support-spacex/in/12838307), food, water, plumbing, or breathable air — things that people need to survive anywhere, and especially on an inhospitable planet with almost no oxygen and where average temperatures hover around minus 81 [degrees Fahrenheit](http://quest.nasa.gov/aero/planetary/mars.html).

Covering all of that ground in a one-hour speech is a tall order. But [by not addressing the human and monetary demands](http://www.theverge.com/2016/9/28/13086980/spacex-elon-musk-mars-plan-problems-breathing-radiation-death) of interplanetary travel, Musk made it hard to tell [just how feasible his vision really is.](http://www.theverge.com/2016/9/28/13087110/spacex-elon-musk-mars-plan-habitat-radiation-funding-questions)

We’re still waiting for a plan to take flight

**Do we have a winner?**

All these plans are still just that — plans. The idea of putting humans on Mars has been kicking around for years, and no one has gotten there yet.

One flaw many of the plans share is that they focus on the trip to Mars and not on how to support life there. After all, we’ve barely managed to survive the Antarctic, and that’s a lot closer to home. "There’s a whole host of issues," MIT’s Do says. "Many we won’t even realize until we actually go and do it."

No single group will have everything it takes to get to Mars

Maybe that means that SpaceX’s role in the journey to Mars will be to set up an efficient, reusable transportation infrastructure. But it’ll be up to NASA, or a new player that has yet to join the race, to figure out how to create a habitable, and sustainable settlement on the Red Planet.

One thing’s for sure: no single group will have everything it takes to get to Mars — especially when it comes to money. Private companies will continue to need government funding to drive their space projects, says [Donald Rapp](http://home.earthlink.net/~drdrapp/), co-investigator of the MOXIE project and a consultant for MIT and JPL. "I think that the economy is a relentless problem in Washington, and getting support for billions of dollars to send humans to Mars is a difficult political thing," Rapp says. But, he adds, at 82 years old, his perspective might be a little different from Elon Musk’s.

"Old guys like me are always thinking about what could go wrong. I think it’s young people — and Musk is half my age — who can look beyond those immediate barriers and have the vision, and the energy, to see how to solve these problems."